United States Antarctic Program
McMurdo Station New Lodging Facility Design and Energy Considerations

National Science Foundation
Office of Polar Programs

ABSTRACT

Existing facilities at McMurdo Station are 1960s and 1970s legacies of the original station developed by the US Navy in an era when the cost of energy was extremely low, and the resources to support the military presence operating the station were seemingly unlimited. The station development at that time was predicated upon quickly accommodating a large human footprint required to launch and support a growing population of both support staff and scientists. The need for expediency drove planning efforts, and readily available non-site-specific materials were incorporated into designs and construction, with little or no consideration for long-term energy or operational efficiency…or the unique environment of the station. Those early plans and designs resulted in energy-inefficient facilities, necessitating large amounts of fuel to be continually shipped to Antarctica to heat and power them. However, at the time, fuel costs and shipping it were considered inconsequential.

After the many decades that the Navy operated McMurdo, the US National Science Foundation assumed responsibility for the station, inheriting a portfolio of facilities, utilities, and infrastructure that were beyond the end of their useful lives and were simply outdated. Over time, the cost of fuel and its delivery increased, as did the facilities' maintenance and repair costs, which translated into more of the Program's operating budget being directed to support these requirements. A "reset" was authorized to contain these ever-increasing maintenance costs, with a master planned and strategically sequenced rebuild effort of replacement facilities. Discussed here is one of them, the Lodging Facility, which is currently under construction. The Lodging facility is a stand-alone building that includes single and double rooms, which will be constructed on-site, using a Design/Build approach and one of the first replacement facilities planned for the station.

To ensure energy efficiency in the design and construction of this and the other new buildings, various comparative methods were used, including benchmarking of other national programs' buildings, evaluating current and emerging energy codes, construction materials, and fabrication and delivery techniques, comparing building envelope options, not limited to walls, roofs, and floors, but also doors, windows, louvers and other building skin penetrations that contribute to energy loss. In addition, various heating and lighting strategies, along with other building systems, were evaluated and considered to determine cost-effective solutions for energy reductions in the replacement facilities. Below are some of these considerations.

METHODOLOGY: Component/System/Assembly Evaluation

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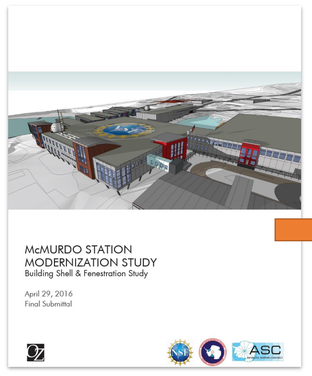
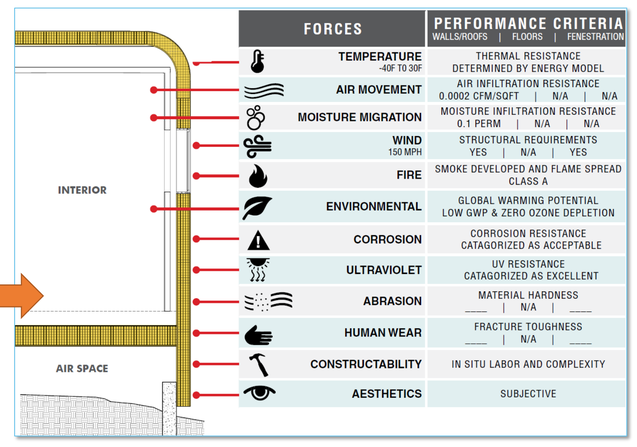
Formal Pre=design Studies





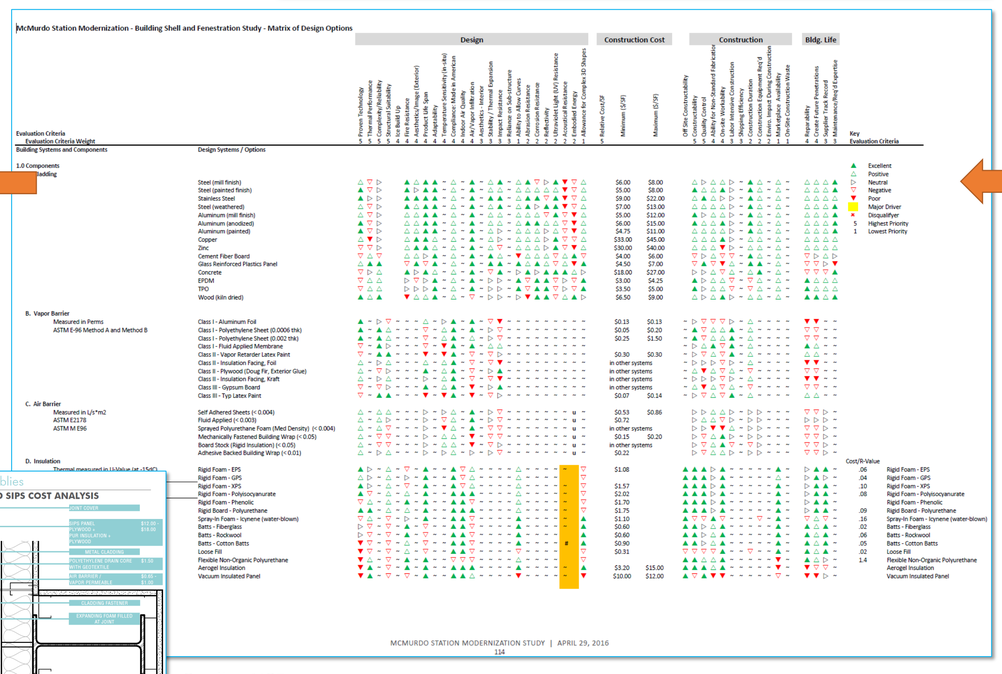
Credits: NSF

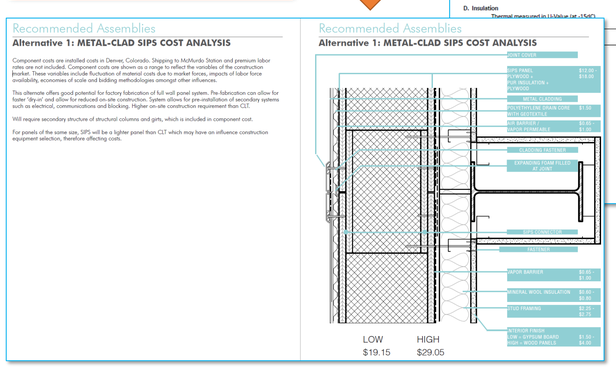
…and a sample of a ranking matrix

MCMURDO EVALUATION CRITERIA EXPLANATION OF RANKING		
CATEGORY	**HIGH**	**LOW**
CONSTRUCTION		
OFF-SITE CONSTRUCTIBILITY	Skills and techniques suited to standard factory means and methods	New techniques & tools required
FIELD CONSTRUCTIBILITY	Use of simple labor and equipment	Highly skilled labor & special equipment
QUALITY CONTROL	Tight tolerances and consistency readily achievable	Materials prevent consistency tight tolerances and
ABILITY FOR NON-STANDARD CONSTRUCTION	Pre-assembly of components into large building blocks	Components require Labor intensive assembly
FIELD WORKABILITY	Ability to make in the field corrections	Corrections require time and special personnel
LABOR SAVING CONSTRUCTION	Small teams erect large sections	Large teams erect small sections
SHIPPING EFFICIENCY	Multiple assemblies fit within shipping containers	Bulky heavy units that don't stack or fit in shipping containers
CONSTRUCTION DURATION	Weeks	Seasons
CONSTRUCTION EQUIPMENT REQ'D	Readily available equipment used in off-loading ships used in construction	Special large equipment imported for work
ENVIRO. IMPACT DURING CONSTRUCTION	None	Requires controlled environment to build and or special breathing apparatus
MARKETPLACE AVAILABILITY	Several sources for product	Proprietary
FIELD CONSTRUCTION WASTE	None	All products are cut in the field
BUILDING LIFE		
REPEATABILITY	Basic skills & material available to staff	Requires special skills & staff
CREATE FUTURE PENETRATIONS	Cutting & sealing by staff	Requires special tools & materials
SUPPLIER TRACK RECORD	Products stocked and warranted	Custom fabrications by small, young companies
MAINTENANCE/REQ'D EXPERTISE	Simple procedures & products	Complex procedures with specialized products

…definition of ranking

…which led to a series of recommendations.





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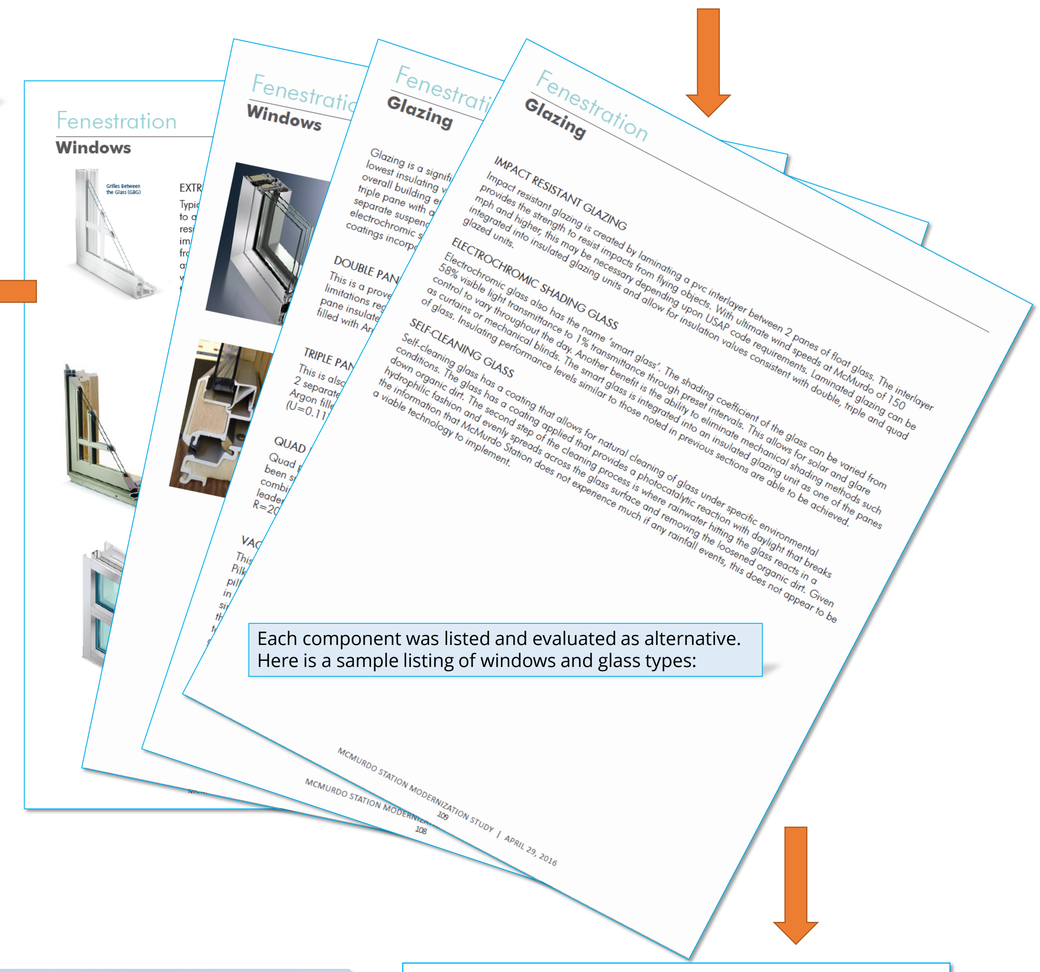

RESULTS

After all viable solutions were thoroughly evaluated, NSF and our partner experts selected building components, assemblies, and systems that would best meet requirements and result in energy and operationally efficient facilities. Included were especially strong thermal envelopes, elimination of thermal bridging, and assemblies eliminating condensation inside the building on exterior surfaces. Energy modeling was then accomplished on the proposed designs to determine initial and operational costs for the life of each of the buildings.

The energy use intensity (EUI, kBtu/sf/yr) of the proposed design has been benchmarked against both the existing McMurdo Station buildings, and a typical lodging building built in this climate zone as represented by the industry standard benchmarking tool, EPA Target Finder.

Data on fuel consumption for McMurdo station electrical and thermal heat production was taken from the ASC Standard Requirements and Equipment report prepared for McMurdo Station, dated September 2018, and translated into an energy use intensity (kBtu/sf/yr) using the gross floor area noted in the report. Note 'equivalent fuel' takes into account the actual fuel use of the building plus the non-fuel energy sources of wind and heat recovery. Per the ASC report, "'Equivalent' is the true measure of energy needed while 'actual' is the measure of fuel consumed." As the energy model results only take into account fuel consumed, 'actual' fuel is used as the benchmark; however, it is important to note that 'equivalent' fuel is 24% higher, indicating an even greater benefit from investing in the energy efficiency measures represented by the proposed design.

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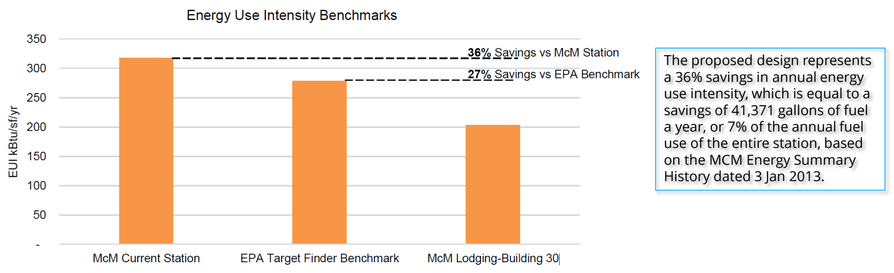
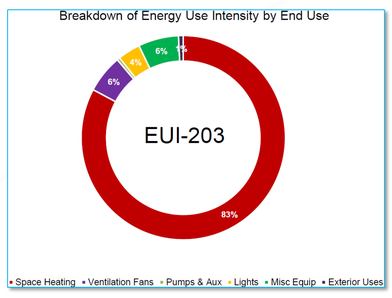
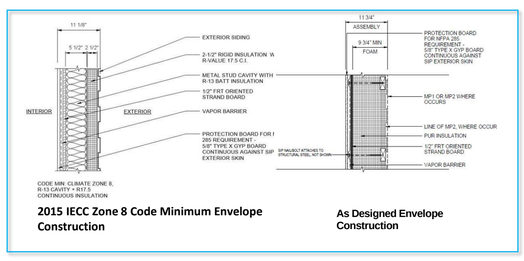


The proposed design represents a 36% savings in annual energy use intensity, which is equal to a savings of 41,371 gallons of fuel a year, or 7% of the annual fuel use of the entire station, based on the MCM Energy Summary History dated 3 Jan 2013.

The design EUI of 203.3 kBtu/sf/yr represents a **36% savings in energy use intensity as compared to the current McMurdo Station overall building efficiency**, and 27% savings as compared to the industry benchmark for lodging facilities in this climate zone, per the EPA Energy Star Target Finder tool.





- Exterior Wall – 8" Polyurethane (PUR) Structural Insulated Panels (SIP) at R-8/inch

Exterior Walls

	R-value
Outside Air Film	0.17
Metal Wall Panel	0.00
8" of R-8/inch	64.00
5/8" Gyp Board	0.56
Inside Air Film	0.68

R-Value	**65.41**	$(ft^2 \cdot ºF \cdot hr)/BTU$
U-Factor	**0.015**	$BTU/(ft^2 \cdot ºF \cdot hr)$

- Roof
  - Lodging – 6" PUR SIP at R-10/inch
  - Core – 8" PUR SIP at R-10/inch

Roof - Lodging

	R-value
Outside Air Film	0.17
Metal Wall Panel	0.00
Plywood	0.78
6" of R-10/inch	60.00
Plywood	0.78
Inside Air Film	0.68

- Soffit – 8" PUR SIP at R-8/inch

Soffit

	R-value
Outside Air Film	0.17
Metal Wall Panel	0.00
8" of R-8/inch	64.00
5/8" Gyp Board	0.56
Inside Air Film	0.68

R-Value	**65.41**	$(ft^2 \cdot ºF \cdot hr)/BTU$
U-Factor	**0.015**	$BTU/(ft^2 \cdot ºF \cdot hr)$

- Glazing – Insulated, multi-pane, glazed units with low-E coatings. The solar heat gain coefficient (SHGC) and visible light transmittance (VLT) proposed values were not identified so baseline values in accordance with IECC-2015 in Climate Zone 8 have been used for this energy modeling effort.

	U-Factor	SHGC	VLT	Conductance
	$BTU/(ft^2 \cdot ºF \cdot hr)$			$BTU/(ft^2 \cdot ºF \cdot hr)$
Lodging	0.14	0.45	0.6	0.152

Credit: NSF

Ben Roth, NSF Facilities Engineering Projects Manager
broth@nsf.gov